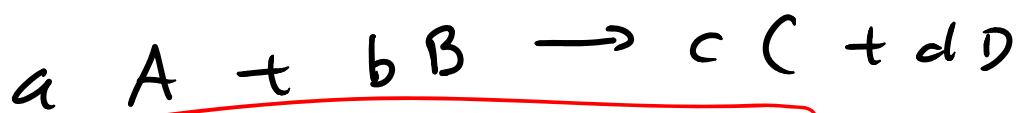


Rate law I: algebraic method



$$\text{rate} = k [A]^\alpha [B]^\beta$$

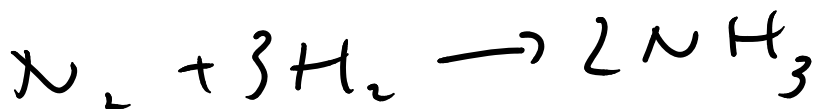
- the value of α & β
 - can be any value
 - not related to a & b
 - determined by experiment (or "theory")

• $\alpha + \beta$: order of the R_n

• α : " " " with respect to ^A

• β : " " " " ^B

problem: find rate law for the R_n



$$\text{rate} = k [N_2]^\alpha [H_2]^\beta$$

i.e. find the value of α, β, k
(including units)

based on the below hypothetical experimental data

expt	initial rate	$[N_2]$	$[H_2]$
1	0.2 mM/sec	1 mM	1 mM
2	0.4 mM/sec	1 mM	2 mM
3	0.8 mM/sec	2 mM	1 mM

Steps

- 1) evaluate the ratio of rates, where there's only one unknown variable
- 2) repeat for other exponents in the rate law
- 3) subst into rate law to find k

note: $aA + bB \rightarrow cC + dD$

$$\frac{r(1)}{r(2)} = \frac{k[A(1)]^\alpha [B]^\beta}{k[A(2)]^\alpha [B]^\beta}$$

$$\frac{r(1)}{r(2)} = \left(\frac{[A(1)]}{[A(2)]} \right)^\alpha \left(\frac{[B(1)]}{[B(2)]} \right)^\beta$$

$$i) \frac{r_2}{r_1} = \frac{0.4 \text{ mM/sec}}{0.2 \text{ mM/sec}} = \left(\frac{[N_2(2)]}{[N_2(1)]} \right)^\alpha \left(\frac{[H_2(2)]}{[H_2(1)]} \right)^\beta$$

$$2 = \left(\frac{1 \text{ mM}}{1 \text{ mM}} \right)^\alpha \left(\frac{2 \text{ mM}}{1 \text{ mM}} \right)^\beta$$

$$2 = 2^\beta ; \boxed{\beta = 1}$$

$$ii) \frac{r_3}{r_1} = \frac{0.8 \text{ mM/sec}}{0.2 \text{ mM/sec}} = \left(\frac{[N_2(3)]}{[N_2(1)]} \right)^\alpha \left(\frac{[H_2(3)]}{[H_2(1)]} \right)^\beta$$

$$4 = \left(\frac{2 \cancel{\text{m}}^4}{1 \cancel{\text{m}}^4} \right)^{\alpha} \left(\frac{1 \cancel{\text{m}}^4}{1 \cancel{\text{m}}^4} \right)^{\beta}$$

$$4 = 2^{\alpha}; \quad \boxed{\alpha = 2}$$

$$\text{iii) rate} = k [\text{N}_2]^{\alpha} [\text{H}_2]^{\beta}$$

$$r_1 = 0.2 \cdot 10^{-3} \frac{\text{M}}{\text{sec}} = k (10^{-3} \text{M})^2 (10^{-3} \text{M})$$

$$= k 10^{-9} \text{M}^3$$

$$k = \frac{0.2 \cdot 10^{-3} \cancel{\text{M}}}{\text{sec}} \frac{1}{10^{-9} \cancel{\text{M}}^3}$$

$$= \frac{0.2 \cdot 10^6}{\text{M}^2 \text{sec}}$$

iv)

$$\text{rate} = \frac{0.2 \cdot 10^6}{\text{M}^2 \text{sec}} [\text{N}_2]^2 [\text{H}_2]$$